

XXIII.—On the Ventriculidæ of the Chalk; their classification.
By J. TOULMIN SMITH, Esq.

[Continued from p. 48.]

Descriptions of species.

Family VENTRICULIDÆ.

Character. Structure. Polypidom membranous: membrane composed internally of fibres arranged in several—usually five*—layers of cubic squares, equal, for the most part, in the plane of thickness and of superficies, and connected at all their angles by other fibres having a regular octahedral arrangement: exterior to this, both within and without, a dermis composed of a single layer of smaller squares, and in which the polyps are lodged, usually on both surfaces: exterior to this a simple epidermis: roots distinct, less regular in structure and without octahedral fibre.

Habit. One or more central cavity, the principal opening to which is at the top: roots ensheathing base of polypidom and extending below into radicles; never affixed to solid bodies.

The details which have been already given render further observations on the characters of the family unnecessary.

GENUS VENTRICULITES.

Character. Pouch-shaped; varying greatly in size and dilatation: cavity single and regular: membrane forming the wall of the cavity either simple and smooth on both surfaces or more or less closely and regularly folded (thus giving it a rugose character): margin of wall thinned or rounded off to an edge: polypiferous on both external and internal surface.

The structure of all the Ventriculidæ is obviously designed for the purpose of securing permanence of form, and thus safety and free access of water to all the individual polyps. This object is effected by two means: first by the very remarkable structure of the membrane already described; secondly, by the regular, often nearly hemispherical figure which the whole body assumes.

Specimens of *Ventriculites* are found of all sizes, and it can easily be understood that, from the earliest period of their development, the same, general form is assumed, which, as they increase and spread, is still retained. Thus the question of their growth

* I believe it to be always five; but the difficulty which exists, from the causes already named, in ascertaining these minute points in all individual instances induces me thus to qualify the generality of this character.

seems to involve fewer difficulties than, at first sight, strike the observer in respect to the other genera.

The access of sea-water was well secured in this genus, inasmuch as, though the folds of some species are close, the expansion of the whole mass and relative size of the central cavity are usually greater than in any other genus, thus compensating for the frequently looser nature of the fold in the other genera. It may perhaps be inferred that the ocean in which this genus dwelt was subject to such modifications that its waters were less liable to disturbance than those of the ocean in which *Cephalites* and *Brachiolites* originated; so that a larger size could be attained in safety, and with less multiplied provision for security against such disturbances.

The whole genus *Ventriculites* is characteristic of the upper chalk. I have a few specimens which may possibly have come from the middle chalk*; but every such case is doubtful, while I have carefully ascertained that the mass are certainly from the upper chalk.

§ a. *Simplices.*

Inner and outer surfaces corresponding.

1. *Ventriculites simplex.* Pl. VIII. (vol. xx.) fig. 1†.

Membrane simple and without trace of fold: moveable processes minute or absent.

This is the type of the whole family, and it is a most happy circumstance that it exists. That existence at once destroys all the theories as to the anatomy and physiology of this group of fossils which have been suggested from examination of some special forms only; while it affords the means of demonstrating some important points. It appears to be a rare species, as, though I am fortunate in having myself obtained a very perfect series, I have certainly never seen half a dozen specimens out of my own cabinet.

When the underskin and polyp-skin are absent, as most often happens, the surface, if uninjured, is particularly beautiful. It exhibits, over its whole surface, with the utmost regularity, that square arrangement of fibre, with the subtending octahedra, already described. When the underskin is present without the polyp-skin the squares are not seen, but the whole surface is covered

* See Ann. and Mag. Nat. Hist. vol. xx. p. 337.

† It is not possible to give illustrations, in this work, of all specimens of full size, several of them often exceeding in diameter the size of the page. It will be understood, therefore, that all the specimens of the present genus figured on Pl. XIII., with the exception of fig. 9, are of specimens below the usual size.

with a much smaller-meshed tissue which appears dotted all over, the dots being the polyp-cells. When the polyp-skin is present it hides each of these appearances, and is marked only with slight depressions in the places where the dots are seen under the conditions last named.

The traces of the moveable processes appear slight, often quite wanting, in this species. This is what might be expected if the object of those processes was to sweep the surface clear of obstructions from the mouths of the cells. The surface being plain, such obstructions would be far less liable to accumulate around it than near those rugose surfaces which other species present, and on the most rugose of which the processes are most strongly marked.

I have specimens varying from 7 inches to 1 inch in diameter.

It appears to me that the fossil called by Dr. Mantell *Spongos Townshendi* (South Downs, p. 164) is nothing more than a *V. simplex*, in flint.

2. *Ventriculites impressus*. Pl. VIII. (vol. xx.) figs. 2 & 3*.

Membrane more or less slightly folded at upper part, but generally without regular figure: moveable processes frequently conspicuous.

The basal portion of this species is usually plain like *V. simplex*, but it soon exhibits marks of fold. These are sometimes slight, sometimes deeper. They vary much in different specimens, so that it might be thought advisable to distinguish varieties. It has seemed to me, however, better to include all under one name only. They may be generally known at once by the basal portion being quite plain as in *V. simplex*; by the much less depth of the folds than in the next species; by the depressions being usually more or less oval instead of round; and by the want of any regular figure in the arrangement of the folds.

This being the first species in which the membrane is folded, it will be well to consider the principle, if any, upon which the fold in all the *Ventriculidæ* is arranged; and also to inquire whether the polyps existed, during the life of the animal, over the inner parts of all the folds.

To treat of the latter question first: I have already intimated that, as a general rule,—exceptions may, as in *Eschara* and *Flus-*

* The object of fig. 2 is to illustrate the very deceptive appearances which the difference in the state of perfection of the fossils will occasion. On the lower part of that figure all remains of the actual body are lost. On the upper part an *Ostrea* is seen, and, near it, a small part of the actual body remains. The difference between this and the rest of the figure must be very apparent.

tra, be found to this general rule,—both external and internal surfaces of the Ventriculidæ were polypiferous. And notwithstanding the closeness of the folds in many species, I believe that the inner parts of all the folds were polypiferous also. The inquirer familiar with recent Polyzoa will find no difficulty in realizing this as true, as he will be aware that these minute creatures are often packed in spaces so close, that it would seem to be, and perhaps is, impossible that all should be protruded at the same time. This fact has attracted the attention of all observers. Dr. Farre notices that the individuals of *Halodactylus diaphanus* “are so closely set that there seems to be hardly room for their several operations;” and that, on this account, it is often “scarcely possible to make any observations upon them” even with the microscope*. And the most recent writer on the Polyzoa, Sir J. G. Dalyell, in his ‘Remarkable Animals of Scotland,’ calls attention several times to the extreme complexity of the mass and to the difficulty of even microscopic observation on that account †. And in the plates of both these writers (pl. 25. fig. 1, Farre; pls. 43, 44 A, &c. Dalyell) the same fact is well shown. It thus becomes obvious that, in recent allied forms, individuals are packed in positions quite as close as, if not closer than, in any of the Ventriculidæ, and in positions apparently more hazardous to the free action of the individuals themselves, inasmuch as the form of the recent species specially referred to is less fixed and unyielding than, from the very nature of their structure, the Ventriculidæ have been shown to have necessarily been.

Having thus shown that there is no improbability that in fossil forms the surface should have been thus closely covered, in all its parts, by the polyps, I will add, that the results of positive observation establish the fact that the inner parts of the folds in the Ventriculidæ were thus polypiferous. I have carefully dissected several folds in specimens, both in chalk and flint, in which the fold is the closest of any species, and I have found, by aid of the microscope, the presence of the polyp-cells clearly and unequivocally marked.

With respect to the arrangement of the fold, the elaborate dissection of many individuals of more than thirty different forms of Ventriculidæ has fully satisfied me that here, as elsewhere, UNITY is prevalent; and that the fold of the membrane forming the wall of the pouch is not capricious and without method or principle, as at first sight it might appear. I have fully satisfied myself that every form and variety of fold ‡ which different

* As before, p. 405.

† See, *inter alia*, pp. 233, 234, as to *Cellularia loriculata*.

‡ It is necessary to distinguish the folding of the membrane forming the

species of *Ventriculidæ* exhibit is based on a modification of the simple *plait*. Unimportant as the question may, at first sight, appear, it is in reality of much importance. Every illustration of the Law of Unity is, and ever must be, interesting to the student of natural history, and important as the surest indication that some point of truth has been attained. And without the guide of some simple unity of this nature, it would be quite impossible to make the structure of the different species of *Ventriculidæ* understood by the inquirer. The multiplied dissections which I have made is a labour which few would have the inclination, and as few the opportunity, to undergo.

In the present genus and section we shall meet with one species in which the form of the simple plait is found without any modification. In the present species, and in several others, the primitive plait is not so obvious; but the comparison of several specimens, and especially, as is so often the case in the illustration of a Law of Morphology, of particular instances assuming a somewhat abnormal character, will enable the careful observer to trace, even in these species, this primitive plait. The limits within which I am necessarily restricted prevent me from entering more fully into, and illustrating at greater length, this question,—which I certainly regard as one of very much interest and importance. In the present section of the genus *Ventriculites*, in which every depression of one side answers to an entirely or nearly corresponding depression on the other, the existence of the plait is less material to the understanding of the character of the wall of the pouch than where the fold assumes that complexity which it does in the section *Complicati*. I shall dwell only slightly upon the point, therefore, in describing individuals of the present section, leaving the fuller illustration of it to those specimens from which the illustrations of Pl. XIII. figs. 13, 14 and 15 are drawn, and which will I hope satisfy every careful and candid inquirer that the most apparently differing external forms may depend on the different modifications which the upper and lower fold of a simple plaited membrane may undergo.

3. *Ventriculites quincuncialis*. Pl. VII. (vol. xx.) fig. 7, and Pl. XIII. fig. 11.

Membrane deeply folded, usually from base to margin, of nearly equal width the whole depth of the fold, and in regular quin-

wall of the pouch, where the whole body is a single pouch, from the subdivision of the body itself into distinct *lobes* or *branches* as found in *Brachiolites*. It will presently be seen that the wall of these lobes and branches is marked by the same characters as the wall of the single-pouch forms now under more immediate consideration.

cuncial figure : moveable processes conspicuous : wall often thick.

In this, as in the former species, must be included forms which, at first sight, vary to a considerable extent, but which I conceive to mark either distinct varieties or distinct ages. It is however almost impossible, in specimens in a good state of preservation, to mistake the species, the characteristic type of fold being found in all with little variation. The wall is usually much thicker than in *V. impressus*, and the fold begins from the base. In some specimens the fold is so deep that a thickness of nearly two lines, —sometimes even more*, —is attained in the wall of the pouch. The folds are almost equally broad down their whole depth, so that in this species the general aspect, both external and internal, is level, contrary to what takes place in *V. muricatus*, and which difference will best be understood by comparing figs. 11 and 12 of Pl. XIII. which represent sections of these two species †.

It occasionally happens that the outer surface is not quite so regularly marked as the inner, though still each depression on one side is accompanied by a corresponding elevation on the other. This variance is probably owing to some circumstance connected with the process of the fossilization of the individual. Hence even a partial angularity in the margin of the folds is, in some such specimens, seen on the outer surface of the wall of the pouch. Such specimens appear to have been partly crushed before or during fossilization. The inside preserves all the usual regularity of the fold.

It occasionally, though rarely, happens that the quincuncial figure is not maintained ; in all specimens there must necessarily be places where it is not truly kept, owing to the mode of increase of the animal from base to margin.

The so-called *Ocellariæ*, so often mentioned, belong to this species. What are thus named are either young specimens, or the lower parts of full-sized ones. These are usually nearly cylindrical at the upper part and taper very gradually to the base ; or form, altogether, a very acutely pointed inverted cone.

There is no species which affords more entire disproof of the contractile theory than this. It is obviously impossible that any membrane should contract in the way in which this form exists, —and with no variation whether forming a close cylinder or an almost flat disc.

I am well-aware that this is the species to which appeal will always be made in opposition to the views which have been stated

* I have an instance in which the thickness of the wall exceeds a quarter of an inch.

† In the specimen figured on Pl. VII. vol. xx. fig. 7. the folds are unusually narrow, but the quincuncial character is well-displayed.

as to the fold of the membrane. It will often be triumphantly referred to as affording evidence of perforation. There may be no *primâ facie* reason why the Ventriculidæ should not, like the recent *Retepora*, have been perforated. When however it is found, through a vast number of differing forms, that one plan, that of the folded membrane, has been unquestionably adopted; and when it is found that in no other case in which Ventriculitic structure is present is a thickness of more than five of the solid squares attained by any part of the fold which forms the wall of the pouch, while it is found that, in this species, the thickness of the entire wall *varies* from one line to three lines,—thus exhibiting, if the actual wall be but a perforated mass, the extraordinary and, upon every principle, anomalous fact of there being no *constancy** in the structure of the central polypidom; there is certainly every reason to conclude that Unity is not violated in this case, and that, like others of the family, this is truly a folded and not a perforated membrane. The various deceptive appearances which the mere fossil may put on have been already more than once remarked. In the examination of the present species, above all, the greatest skill and care are necessary, because it is obvious that the very depth and narrowness of the fold must, if any abrasion or injury of the external surface† take place, destroy the traces of the membrane covering the top of each depression, and because the small size of the depressions and elevations renders it very difficult to follow the fold which forms them from one surface to the other. Feeling therefore to the fullest extent the difficulty of ascertaining the actual *fact* in this case, and at the same time the importance of ascertaining that fact, both as an exception, if it should prove such, to the Law of Unity, and as a determination of a point in palæontology which has been now mooted for more than thirty years, I carefully dissected numerous specimens, both in flint and in chalk, and both with the slitting-wheel and the needle, and followed up and down the so-called (sometimes) cells or (sometimes) perforations to their terminations. The clear and unequivocal result has been that the so-called *Ocellaria* is no anomaly: that the Law of Unity has not its exception here; that this is a true case of fold of membrane: finally, that I have at this moment before me specimens in which

* It will be obvious to the careful inquirer that there is nothing anomalous in the varying depth of the folds, inasmuch as, in all species, that depth will naturally be dependent, more or less, on the age of the individual.

† In every instance, both in chalk and flint, with very rare exceptions, some of the body adheres to the matrix. In the present species, where the bases of the folds are so small, it will necessarily, therefore, often happen that just those bases adhere to the matrix. Hence alone will result an apparent perforation of the wall, the remains of the membrane not being present, and not therefore traceable, over those bases.

I can as clearly see the fold in and out of that membrane as it is seen in fig. 11. Pl. XIII. I wish to be specific and precise on this point because I know that a bare description will be questioned. I am obliged to state that such a reality as is represented "magnified" on p. 279. fig. 2 *b* of Dr. Mantell's 'Medals of Creation' never had existence* in the nature of the animal of which fig. 2 gives a view of the natural size of the fossilized remains.

In the museum of the Yorkshire Philosophical Institution there is a fragment of a specimen of this species almost discoidal, which still measures more than nine inches across, and, when entire, must have been of still greater size. This is an unusually large size for the species to attain, but the variation in that respect is very great. There is another interesting specimen of this species in that museum in which the whole body has become converted into chalcedony. The outer surface is nearly entire, as is also a considerable part of the inside. The structure is, as usual in solidified chalcedonic specimens †, obliterated throughout the greater part, but it can, in places, be still clearly traced. The individual underwent pressure before or during the process of fossilization, and also some decomposition, so that the external character has become somewhat modified, and it is only in parts that the internal arrangement can, at places of section, be seen. The peculiar state of the specimen,—solidly chalcedonic without the presence of any true flint,—renders it however very interesting ‡.

4. *Ventriculites muricatus*. Pl. XIII. figs. 1 & 12.

Membrane deeply folded, without regular figure: folds unequal in width throughout their depth: moveable processes often conspicuous: wall of moderate thickness.

The point wherein this species differs most essentially from the last will be at once understood by comparing figs. 11 & 12 of Pl. XIII. It has been already explained that, through the uniformity in the breadth of the fold, the general surface of *V. quin-*

* And see p. 280: the polyparium of this species is no more "calcareous" than that of any other of the *Ventriculidæ*. Treated with acid it is acted on in precisely the same way and to the same extent as are all specimens of *Ventriculidæ* preserved in flint, and leaves an exquisitely delicate cast of the body of the animal and of the structure of its polypidoni.

† See before, p. 85. vol. xx.

‡ It has already been stated (vol. xx. p. 86), that "in general when any part of the soft substance of a body encased in chalk decomposed, its place was soon filled up with particles of chalk." The above instance is one of the rare exceptions to this general fact; and the peculiar condition of the Yorkshire chalk (which is much more compact than that of Kent, &c.) may lead us to expect more numerous instances of these exceptions from that region than from the chalk of the south-east of England.

cuncialis is smooth. It will be perceived that where, as in fig. 12, the folds are broad on each surface at their margin and narrow to a point at their base, the effect must be to give to the whole wall of the pouch a rough surface. The wall is usually not very thick. I have never seen it attain so great a thickness as *V. quincuncialis* often does. The height and depth of the folds render it difficult ever to confound it with *V. impressus*, in which also the same smooth general appearance of the surface as in *V. quincuncialis* is usually maintained, and for the same reason as in that species.

5. *Ventriculites tessellatus*. Pl. XIII. figs. 2, 3, 4.

Membrane folded in regular quadrilateral and rectangular figures usually more or less oblong: wall of moderate thickness.

In Mr. Morris's Catalogue mention is made of a *Ventriculites quadratus*, and reference is made to Goldfuss, pl. 33. fig. 1. I have already* stated that this is no *Ventriculite*. The description is, "*seriebus pororum oblongorum rectis parallelis decussantibus*,"—an error into which I cannot conceive it possible that Goldfuss could have fallen if he really had the present species before him. And the magnified sketch given in fig. 1 *b* of the same plate,—unless fancy and not actual observation be there copied,—differs as widely from any characters of the present species, and from any form of *Ventriculitic* structure, as does the description which has been cited.

This form is rare; and it is still rarer to find a perfect specimen. I have several fragments, excellently well displaying structure and fold, and during the summer of 1847 I was fortunate enough to find a perfect specimen, with roots and margin, and both body and cast, entirely perfect, and five inches in diameter; but I was so unfortunate as for it to break in pieces before I could convey it home, a danger to which the collector of these delicate fossils is peculiarly liable. Though this loss is not easily to be replaced, the opportunity of verifying the entire form of the species was important. The rarity of the species has prevented me from making sufficiently extended observations on the moveable processes to state, with confidence, anything definite in regard to them.

In this species the plaits may often readily be traced, with the oblong depressions running along them on each face of the wall. This being borne in mind, the figures often displayed on section will readily be understood, when, instead of the regular alternation of depressions seen at one place of section, as in fig. 4

*. Ante, vol. xx. p. 78.

(Pl. XIII.), the character represented in fig. 3 will, at another place of section, be seen.

6. *Ventriculites cavatus*. Pl. XIII. fig. 5.

Membrane folded in concavities of considerable breadth, rarely regular in disposition: wall of moderate thickness: moveable processes often well-seen.

This species can never be confounded with the last. The shape of the fold, its sloping edges, and the want, in general, of regular figure, at once distinguish it. A linear arrangement of the depressions is often traceable, marking the places of the primitive plait.

This species might readily be divided into two or three varieties, marked by the fewness or abundance, the small or large size, and the greater or less degree of regularity, of the folds. The principle of the fold,—which in all cases is the groundwork of the present classification,—appears however to be the same in all these cases, and they may, not improbably, be but modifications indicative of a difference of age. The concavities are usually somewhat elongated in specimens of which the pouch is closely cylindrical.

In this case, as in all others, it is necessary that both sides, or a good section, of the specimen should be examined, as *V. radiatus* will be found to be marked on the inner surface by characters bearing some superficial resemblance to those distinguishing both surfaces of the present species, while *V. bicomplacatus* bears, both on the external and internal surfaces, characters which may sometimes mislead the observer. A section of the present species however will show the wall much thinner and the cavities shallower than in either of those species, while, in well-preserved specimens, the entirely different character of the fold cannot fail to be seen.

7. *Ventriculites striatus*. Pl. XIII. figs. 6 & 13.

Membrane folded from base to margin in regular close and simple plaits: processes very conspicuous: wall of moderate thickness.

This is an exceedingly interesting and very marked species. The plaits, which have heretofore been traceable only by careful comparison and an effort of induction, become in this species the one characteristic feature. Not a trace is present, on either surface, of the "tubuli"—assumed to be polyp-cells or absorbents—of Dr. Mantell, and the presence of which is expressly stated by him to be characteristic of the genus and species*; upon the assumption of which indeed all his views and descriptions have

* See ante, vol. xx. p. 77.

been based. The inquirer will be well-prepared for this entire absence of any such tubuli from its having been seen that, in the preceding species, the depressions (which alone are what could, even on a superficial observation, be called tubuli) have the greatest diversity of form and character, a diversity which at once negatives their being of the nature assigned to them by Dr. Mantell. It has moreover been seen that, as a matter of fact, they are in no instance tubuli, but that they can, on the contrary, be traced as folds of the membrane forming the polypidom itself.

On the other hand, the present is the only species which could seem to lend any support to the contractile theory. The observer however who has studied the several preceding species will probably ask for no proof that the present does not stand out as an anomaly and an exception from them all. If he need such, he may be referred to the observations already made*, generally, on the matter. These have full application in this as in every other case, and sufficiently show that this species offers no violation to that Unity which prevails through every branch of the present inquiry.

Different specimens vary in the size and depth of the plait. It is suggestive, perhaps, as before, of difference of age. It is where the plait is deepest and broadest that the moveable processes become most conspicuous.

The plaits are not narrow at the base and of increasing size as they approach the margin. They maintain the same size from base to margin, and the increase of surface is effected by the increase in number of plaits as the margin is approached; an increase effected by the division, from time to time, of one plait into two,—each of equal size with the original one,—a mode of increase which generally prevails in all species in which the plait can be distinctly followed. The species is not common.

§ *b. Complicati.*

Inner and outer surfaces not corresponding.

1. *Ventriculites mammillaris.* Pl. XIII. figs. 7 & 14.

Inner plaits simple and regular: outer plaits raised in large hollow bosses at regular intervals: processes very conspicuous: thickness of wall considerable.

This is the first instance in which we find the direction of the fold changed between the external and internal surfaces. There is no species more strongly marked, and none which affords a better illustration of the value and importance of a principle of Unity as the essential and most valuable means to true scientific

* Ante, vol. xx. p. 89.

research. The fact of the mammillated external appearance of this species is easily seen and as easily recorded: so is also the fact of the striated internal appearance. But it would be difficult, by any description, to make it clearly understood how such apparently contradictory appearances could result from the folding of a simple membrane*, until it had been ascertained, by careful and multiplied dissections, that this and all other characters of the fold of the membrane forming the wall of the pouch are grounded upon one single and simple unity of plan of which all present clear and intelligible modifications.

On the outside of this species as usually seen in a fossil state, and as it must usually have appeared in a recent state, no mark of the plait is seen. Large rounded elevations scattered, at first sight irregularly, over the whole surface, are all that meet the eye. If however the reader will carefully consider figs. 13 and 14 of Pl. XIII. he will see, in fig. 13, the simple plaits, regular and uninterrupted, within and without, as in *V. striatus*; while in fig. 14 he will see that the perfect plait is still present, and that the *inner* surface [the lower part of the figure] is still simple and uninterrupted, but that the *outer* plaits are interrupted along their whole length by rounded elevations,—not solid, but hollow,—elevations of the membrane into those shapes instead of the plait being plain and simple. These figures are somewhat exaggerated in size in order that the principle may be more clearly understood.

It will be found that in each of the forms which follow, and

* As the extraordinary complications in the fold of the membrane of many species were gradually developed by multiplied dissections, I long despaired of being able, by any descriptions, to make them understood. When by degrees the unity of plan which I have endeavoured to indicate above, as the groundwork of all that complexity, opened upon me, I felt an important key to have been obtained, which experiment proved to be applicable to every case. I indulge some hope that the development of this unity may be of a utility beyond the mere understanding of the forms now under discussion—however interesting those may be to myself and others. In the descriptions of numerous tissues in human and other branches of anatomy, I have often myself felt the want of some clear and simple basis of unity in the descriptions attempted of those tissues; which want has caused them to be often unintelligible. Any pains which the investigation of the present subject may have cost will be more than rewarded if the suggestion of an unfailling unity in the arrangement of all complex tissues shall be felt to be (as I cannot doubt that it is) generally applicable. It seems to me, that as, by application of this principle, forms varying so entirely as it will be found that many of the *Ventriculidæ* do in mere general external characters, and therefore heretofore classed in entirely different natural groups, are now demonstrated to belong to one group, so the application of the like principle may, in many points of anatomy, lead to the discovery of intimate relations, not now suspected, between tissues which appear very different in structure.

which appear so widely different from each other in all that meets the eye of the general observer, the characters which each exhibits may be as readily understood as in the present species by taking as the basis that simple Unity of plan which has been thus illustrated.

2. *Ventriculites latiplicatus*.

Folds very broad and deep : outer plaits simple and regular : inner plaits inclining, at intervals, towards, and anastomosing, a little below the surface, with, adjoining plaits : wall very thick.

This is a very interesting species. It presents us with the first instance of the plaits departing from their entire individuality, and of a connexion being formed between adjoining ones. In the present species that connexion is merely by a slight anastomosis at distant intervals. There being no depression in the plait, on either surface, the access of water is perfectly preserved without any additional provision such as we shall find in *V. radiatus* and many others.

In *V. mammillaris* the departure from the simple plait took place on the outside. In the present species it takes place on the inside, and is more marked in its character and degree ; but it is none the less an illustration of the principle of Unity which it has been endeavoured to explain, being clearly but a modification of the simple plait. This will be understood from the following figure, in which *b, b, b* are the lower plaits ; *c, c, c*, the upper plaits ; and *a, a, a*, the points of anastomosis. We shall, in the next species, find the complexity of the fold much increased.

The wall of this species is thicker than that of any other species of the genus *Ventriculites*.

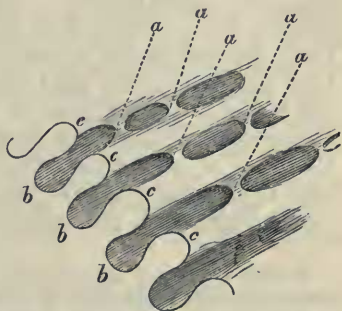
3. *Ventriculites decurrens*. Pl. XIII. fig. 8.

Plaits often irregular in direction : outer plaits constricted at distant and unequal intervals : inner plaits depressed at short and nearly equal intervals ; bulging on each side around depressions till adjoining plaits meet and open into each other : processes conspicuous : wall of moderate thickness.

Var. *tenuiplicatus*. Pl. XIII. fig. 9.

Plaits close and delicate : outer plaits nearly regular in direction

Fig. D.



from base to margin with slight occasional constrictions : inner plaits depressed at regular intervals ; bulging on each side around depressions till adjoining plaits meet and open into each other : processes conspicuous : pouch very often nearly cylindrical : wall thin.

Marked specimens of these two varieties are very distinguishable, but, upon the principles to which I have confined myself in discriminating species, I do not think it proper to separate them ; the elements of the modification of the fold being similar in each variety. Specimens in which the two varieties run into each other are not unfrequently found.

The variety *tenuiplicatus* is a most beautiful and delicate fossil. I have several specimens on which the polyp-cells are finely seen.

In examining each of these varieties the importance of the clue afforded by the principle already explained of Unity in the fold of the membrane becomes strongly felt. Let the reader compare figs. 13, 14 and 15 of Pl. XIII., always remembering that fig. 13 is the basis of every modification. In fig. 15 he will see the *lower* plait [it is immaterial for the present purpose whether that is to be looked at as the inner or outer surface] retaining its simplicity, while along the top of the upper plait he will see a series of circular depressions at short and equal intervals. At the sides of these depressions the membrane bulges out,—in order to preserve the walls of the plait below the depression clear from contact*,—until the bulgings on the two adjoining plaits meet and anastomose. These then open into each other in the centre of the place of anastomosis, leaving, however, below them and on each side a clear space ; so that strength and security are gained to the whole mass, and, consequently, the safety of the individual

* This is but one other among the numberless beautiful illustrations afforded by the anatomy of the Ventriculidæ of obvious design and adaptation. Did these walls touch, there would be a great loss of surface and little or no additional strength. By the actual arrangement there is a vast gain of both surface and strength, as well as an additional security for free access of sea-water to all parts of the inner surface. It has already been seen that this additional provision not being needed in *V. latiplicatus* is not found in that species. It is proper to add, that the fact that, around the depressions, the adjoining plaits do not only anastomose but *open into each other* has been ascertained by most careful examination and dissection of specimens in chalk and in flint ; but that, having clearly ascertained the fact in instances where there is thus such an obvious purpose for such an arrangement, I cannot doubt that, under similar circumstances of structure in adjoining parts, such is always the arrangement of the fold in this particular, though the minuteness of the parts generally prevents the possibility of clearly distinguishing it in chalk specimens. The place of the opening does not usually exceed, in the necessarily somewhat collapsed state in which it is exhibited in the fossil condition, the 40th of an inch in diameter, a space which the iron stain in the chalk is more than sufficient to obliterate.

polyps is ensured, together with a great increase of polypiferous surface.

I am aware of no instance among the Ventriculidæ in which a mere ridge or flap of membrane is added on,—as this would practically be if the membrane forming the sides of these depressions came in contact with that forming the sides of the plaits. There are, on the other hand, very many cases in which, as in the present species, additional strength to the whole mass is afforded by a means which gives a very great additional surface for the development and security of that life, the manifestation and multiplied means of enjoyment of which were the end of the existence of the whole creature.

On each side of the places where these meeting bulgings blend, the vacant spaces between the plaits put on, naturally, from the shortness and regularity of the distance between the bulgings, a circular form. As one of these must, of course, lie between each double pair of the depressions, a quincuncial figure is thus assumed by the whole (see the darker spots in fig. 15 of Pl. XIII.). The inquirer will thus at once understand the appearance presented by the inner surface of many species of Ventriculidæ. He will clearly see that the "tubuli" of Dr. Mantell are things without existence. He will understand that though, at the surface of a fossil of which all the interstices are filled with chalk, all the circular marks appear alike, yet the dissection of alternate rows of them will reveal very different conditions; one row consisting of more or less shallow (in the present species usually rather shallow) and closed depressions; the other having no true depressions at all, but consisting of cavities extending to the bottom of the intermediate plait, and indeed, before and behind, underneath the intermediate bulgings, running into and forming part of the longitudinal cavity of that plait.

The wall of the variety *tenuiplicatus* being usually thin, the depressions on the inner plaits, though shallow, are sometimes to be seen through on the outside, if the specimen has come very clean out of the chalk. It is very rarely, however, that specimens can be got out of the chalk in this clean manner, portions of the matrix usually filling up the spaces between the plaits. In the recent state, and when, instead of being in the collapsed condition in which we find the fossils, the animals were alive and fully distended with all their fluids*, no doubt the lower surface of all the depressions on the top of the inner plaits could be seen from the outside. The living creature must have appeared as composed of a number of plaits which, on their inner surfaces,

* Every reader must perceive the difference between the comparative states of *collapsion and distension* and those of *contraction and expansion*.

exhibited numerous shallow depressions; and which plaits, on each side of these depressions, were united together by small transverse tubules, the mouths of which tubules were directed towards the *outer* surface of the whole body, and opened, always, into the interspaces between the outer plaits.

It will be obvious that sections, whether made longitudinally or transversely to the plaits, will vary in numberless ways in the figure which will be seen, according to the particular point of the plait through which the section passes. This must be remembered when the section seen at the edge of a flint or fractured chalk specimen is examined. This observation applies as well to the present species as to almost every other which will subsequently come under notice.

The plaits of *V. decurrens* are not very regular in their course. On the contrary, the outer plait, where the course is easily traced, is often very winding, though several generally run parallel to each other. The constrictions occur at irregular and distant intervals, and cause the surface to appear as if several of the round elevations of *V. mammillaris* had run together down the surface,—a modification which may truly be considered to represent the fact. Hence the specific name. The constrictions do not extend the whole depth of the plait. They do not appear ever to extend so deep as to interfere with the mode of fold characteristic of the inner surface. It is owing to the winding course of the plaits in this species that the rings seen on the inside do not assume, as in *V. radiatus*, a perfectly regular quincuncial figure; the places of the depressions and accompanying characters of structure varying, of course, in places, as the plait winds. In *V. tenuiplicatus*, where the plaits are more regular, the quincuncial figure on the inside is correspondingly more regular. The constrictions on the outer plaits of that variety are much slighter than in *V. decurrens*. They resemble much more a very slight exhibition of the normal characters of *V. mammillaris*. They thus rarely interfere with the continuous course of the plait.

4. *Ventriculites radiatus*. Pl. XIII. figs. 10, 15.

Plaits broad and deep: outer plaits regular, and with an occasional lateral connection: inner plaits deeply depressed at short and equal intervals; bulging on each side around depressions till the adjoining plaits meet and open into each other: processes very conspicuous: wall thick.

I have retained for this interesting species the name *radiatus* of Mantell, as being the species which comes nearest in superficial external and internal appearance to his descriptions already cited*.

* Ante, vol. xx. p. 76.

This species unites the characters observed in *V. latiplicatus* and *V. decurrens*. In the former mere points of connection exist, on one surface, between the plaits; in the latter the remarkable depressions, bulgings and openings into each other last described exist, also on one surface only. In the present species the latter characters are found on the inside, the depressions being, however, deeper than in *V. decurrens*; while, the plaits being deep, they exhibit, on the outside, and at distant intervals, points of mere connection (no depressions being present on that surface) as in *V. latiplicatus*.

The difference between the constrictions which mark the outer plaits of *V. decurrens*, and the points of connection, without any constriction, which exist between the outer plaits of the present species, is alone sufficient to distinguish the two. In addition to this, however, the present species is much thicker and more massive than *V. decurrens*; it often attains a thickness in the wall of the pouch nearly as great as *V. latiplicatus*. The regularity in the direction of the plaits is another distinguishing character.

Owing to the regularity of the plaits in this species, the figure assumed by the inner folds is very regularly quincuncial.

The inquirer must be careful not to be misled by inspection of an inner surface only into determination of this species, as such surface in either *V. cavatus* or *V. bicomplexatus*, especially the latter, and sometimes in *V. decurrens*, will be difficult to distinguish. It cannot be too often insisted on that parts of both surfaces, as well as sections, should be examined before determining species with certainty.

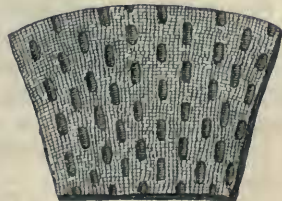
This species is very local in its distribution, being very rare in many places.

5. *Ventriculites bicomplexatus*.

Plaits broad and deep: both outer and inner plaits deeply depressed at short and equal intervals, which alternate in adjoining inner and outer plaits; bulging on each side around depressions till adjoining plaits open into each other: processes very conspicuous: wall very thick.

In the present species we meet with a much greater complexity of fold than in any preceding one. The plaits on both surfaces undergo a marked modification which resembles the modification seen on the inner plaits of *V. radiatus*. The form of the depressions on the external surface are, however, generally oval instead of round, as in fig. E.

Fig. E.



The descriptions which have been given of the mode of fold on the inner surface of *V. decurrens* and *V. radiatus* render it unnecessary to dwell on the nature of the modifications which the present species exhibits, and which are but the reduplication of the remarkable characters exhibited in the species just named. It may be suggested, however, that sections of this species will vary so much, according to the direction in which they are taken, that no one figure can be depended on as certainly indicative of the species, without very extended and careful comparison. Notwithstanding, however, the complexity of the folding in the present species, the application of the observations already made in respect of *V. decurrens* will make it clear that the free access of sea-water would be perfectly maintained to all parts of the very extended polypiferous surface which is thus gained.

In all these deeply folded species we have seen that the moveable processes are very conspicuous. They are thus conspicuous on that portion of the fold which is most exposed. There would obviously not be room for their operation within the folds, and the traces of them are not found there as they are on the external surface. If their object be that which has been suggested*, their presence and action on this exposed external surface would be amply sufficient for the protection of the polyps in the deeper recesses of the folds, and the presence of the processes there would be useless. The absence of their marked development in those parts is therefore in harmony with that admirable adaptation of means to ends which the results of every part of the present investigation have displayed.

In examining the various and complicated forms which have been thus noticed as included within the genus *Ventriculites*, nothing is more striking than to find that, be the wall of the pouch thick or thin, the thickness of the membrane itself remains always the same. It may be folded up in the most complicated way, but it still retains, in any single piece of it, precisely the same characters as have been described as typical in respect to *V. simplex*. Were other facts wanting, this would alone go far to induce the conclusion which other courses of investigation have already seemed to demonstrate, viz. that we have before us a true Polyzoic *polypidom*; and that polypidom one of the most admirable construction and contrivance. No less interesting illustrations of that conclusion will be found in the widely different forms and modifications of folding which remain to be examined.

* Ante, p. 205, and p. 185 of vol. xx.